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SUMMARY of TROPICAL CYCLONE ACTIVITY and FORECASTS in the 1994-5 SOUTHERN HEMISPHERE SEASON

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1. INTRODUCTION

A summary of tropical cyclone activity in the southern hemisphere for the 1994-5 season is presented below together with an assessment of the performance of the global model in predicting the tracks of these tropical cyclones.

Tropical cyclones are experienced in the South Indian Ocean, tropical seas to the west, north and east of Australia and the western South Pacific Ocean. For the purpose of tropical cyclone verification the southern hemisphere is divided in to two basins; the South-West Indian (west of 90°E) and Australian (east of 90°E). Mean error statistics for each basin are presented together with a table of statistics for the whole southern hemisphere. The global model produces a 6-day forecast every 12 hours. Verification is performed at 24 hour intervals up to forecast time T+120.

The present global model has a resolution of 1.25°x 0.83°x 19 levels. This is equivalent to a horizontal resolution of 139km x 93km at the equator. The tropical cyclone verification scheme identifies the centre of a tropical cyclone in the model by locating a local maximum of relative vorticity at 850hPa. A surface fitting technique is used to locate the centre accurately.

The terms used in the statistics tables are explained below :-

Possibly verified - No. of forecasts fulfilling requirements 1, 2 & 4 below.
Actually Verified - No. of forecasts fulfilling *all* the requirements below(*).
Mean DX - Mean of positional errors in the East-West direction.
Mean DY - Mean of positional errors in the North-South direction.
Mean AT - Mean of positional errors in the Along Track direction.
Mean CT - Mean of positional errors in the Cross Track direction.
Skill - Percentage skill of model against CLIPER.
Mean DPE - Mean of direct positional errors.
All errors are measured in kilometres except where indicated.

(*) 1. Observed maximum wind at least 31 knots at the verifying time.
2. Forecast tropical cyclone centre equatorwards of 40 degrees.
3. Forecast tropical cyclone centre relative vorticity above a critical limit for verification (0.55×10^{-4} per second).
4. Observation within 6 hours of verifying time present for use in verification.

Forecast skill is defined as:- $\frac{\text{CLIPER DPE - Model DPE}}{\text{CLIPER DPE}} \times 100\%$

Positive skill indicates the model forecast is better than CLIPER.
Negative skill indicates the CLIPER forecast is better than the model.

A diagrammatic explanation of other error statistics and their sign conventions can be found in Appendix A. Full details of the TC verification scheme can be found in nwp Gazette, Vol.1, No.2, December 1994.

Advisory positions primarily from JTWC Guam are used as verifying observations of storm location when track verification is carried out immediately after a storm has ended. Best track data from RSMC, La Réunion and Bureau of Meteorology, Melbourne have been obtained for this season's storms and the track forecasts verified again. Statistics for verification against best-track observations are presented in detail. Some statistics for verification against real-time observations (from JTWC, Guam) are included for the purposes of a comparison. Some mean error statistics for last season are also included for the purposes of a comparison. Note, the statistics for last season were obtained using real-time verifying observations. Forecast tracks are only verified when a depression reaches tropical storm status.

2.TROPICAL CYCLONE ACTIVITY

	SWI	AUS	TOTAL
Total number active 1993-4	13 (13)	17 (16)	30 (29)
Total number active 1994-5	13 (11)	11 (9)	24 (20)

Basin name abbreviations:- SWI = South-West Indian (west of 90°E)
AUS = Australian (east of 90°E)

The number in brackets indicates the number of depressions which reached tropical storm status (maximum sustained wind above 33 knots).

3. SUMMARY OF ALL SOUTHERN HEMISPHERE STORMS

3.1 South-West Indian Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	122	99	77	59	45	31
Actually Verified	122	97	75	54	41	28
Mean DX	15	-21	-79	-108	-217	-295
Mean DY	5	11	2	41	-4	93
Mean AT	-25	-40	-74	-105	-131	-212
Mean CT	8	6	-18	-43	-110	-164
Mean Skill (%)	****	-6	28	24	****	****
1993-4 Skill (%)	****	-31	-10	10	****	****
Mean DPE	84	176	270	409	570	729
1993-4 DPE *	148	261	402	587	745	870
RT DPE #	59	174	269	405	563	717

* DPE for all South-West Indian storms in 1993-4 season
\# DPE calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 1.

There were two less tropical storms this season than last in the South-West Indian basin. Forecast errors were 16-33% lower and skill scores 14-38% higher than last season. Figs. 2 and 3 show forecast errors and skill scores for the last few seasons and indicate a consistent improvement in track forecasts. There was an overall slow bias in forecasts this season.

3.2 Australian Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	63	46	30	17	7	1
Actually Verified	63	46	26	10	2	0
Mean DX	-19	-68	-147	-202	-538	****
Mean DY	9	35	0	-282	-434	****
Mean AT	-9	-71	-142	-277	-624	****
Mean CT	-6	-25	-89	-219	-193	****
Mean Skill (%)	****	39	41	23	****	****
1993-4 Skill (%)	****	-17	-2	-51	****	****
Mean DPE	62	199	342	462	713	****
1993-4 DPE *	141	267	383	584	879	1163
RT DPE #	55	201	347	460	688	****

* DPE for all Australian storms in 1993-4 season
\# DPE calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig.4.

There were five less tropical storms this season than last in the Australian basin. Forecast errors were 11-26% lower and skill scores 43-72% higher than last season. Figs. 5 and 6 show forecast errors and skill scores for the last few seasons and indicate a marked improvement in track forecasts when compared to figures for the 1991-2 and 1993-4 seasons. This seasons figures were near to or slightly better than those for the 1992-3 season. There was an overall slow bias and a right-of-track bias in forecasts this season.

3.3 Combined Statistics for whole Southern Hemisphere

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	185	145	107	76	52	32
Actually Verified	185	143	101	64	43	28
Mean DX	3	-36	-97	-123	-232	-295
Mean DY	6	19	2	-9	-24	93
Mean AT	-20	-50	-90	-130	-154	-212
Mean CT	3	-3	-35	-68	-114	-164
Mean Skill (%)	****	13	32	24	****	****
1993-4 Skill (%)	****	-25	-7	-2	****	****
Mean DPE	76	184	289	418	576	729
1993-4 DPE *	145	263	395	586	783	930
RT DPE #	58	183	290	414	569	717

* DPE for all southern hemisphere storms in 1993-4 season

\# DPE calculated using real time observations as opposed to best track.

Comments :

The combined statistics reflect the improvements over last season seen in the individual basins. Forecast errors were 22-30% lower and skill scores 26-39% higher. There was a consistent slow bias and a slight right-of-track bias. On average, there was only a small difference between forecast errors derived using real-time observations and those derived using best track observations.

Figs. 7 and 8 show forecast errors and skill scores over the last few seasons. In January 1994 a major change was made to the model physics which may account for the reduced positional errors at T+48 and beyond in 1993-4. However, skill scores at T+24 and T+48 were lower than in the previous two seasons. This season, both positional errors were reduced and skill scores increased over previous seasons. The improvement can be attributed to the new technique for the initialisation of tropical cyclones in the global model which

was introduced in October 1994. For more details of this technique see the following publication:-
"A new scheme for the initialisation of tropical cyclones in the UK Meteorological Office global model" by J.T.Heming, J.C.L.Chan and A.M.Radford (1995). Meteorological Applications, 2, 171-184.

Further Tropical Cyclone Information

The Met. Office pages on the World Wide Web contain information on tropical cyclone forecasting at the Met. Office. Monthly bulletins of tropical cyclone activity and forecasts are held together with observed and forecast track information of recent storms, track prediction error statistics, lists of names, images, movies and photographs and details of advances made in tropical cyclone track prediction at the Met. Office.

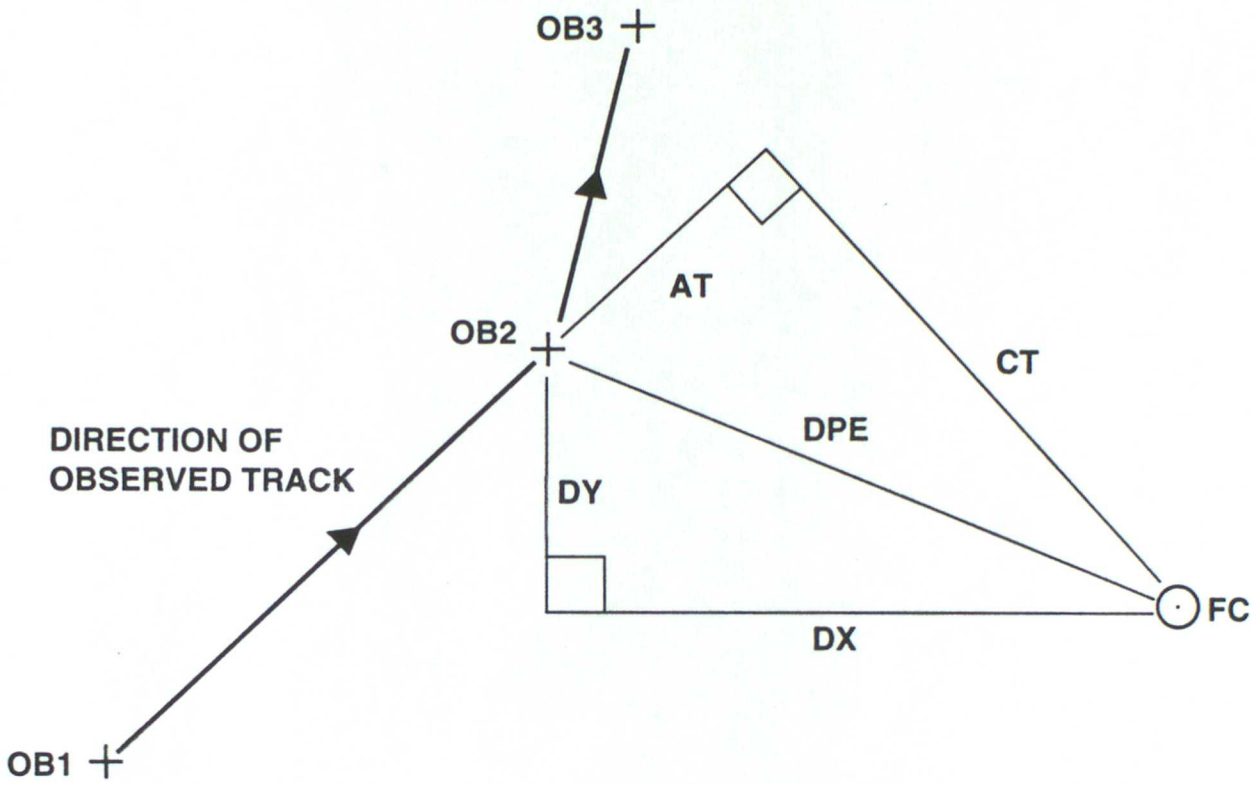
The Met. Office web site is:- http://www.meto.govt.uk
Tropical Cyclone information can be found under the section "The weather & how we forecast it".

The information above is also available on the Met. Office internal web under Julian Heming's home page. Contact Julian Heming (jheming@meto.govt.uk) or Alan Radford (amradford@meto.govt.uk) for further information on tropical cyclone forecasting at the Met. Office.

Acknowledgements
CLIPER models for various basins were supplied by Mr.S.Lord, NMC, Washington, USA and Mr.C.Mauck, FNOC, Monterey, USA.
Assistance with GrADS software given by Mr.S.Lord and Dr.M.Fiorino.
Best track observations for the southern hemisphere were supplied by L.Zerbib (Météo-France, La Réunion) and F.Woodcock (Bureau of Meteorology, Melbourne, Australia).

APPENDIX A

Diagrammatic Explanation of Forecast Errors



OB1-3 : Observed positions
FC : Forecast position verifying against observation OB2
DPE : Direct positional error
DX : Error in the East-West direction
DY : Error in the North-South direction
AT : Error in the Along Track direction
CT : Error in the Cross Track direction

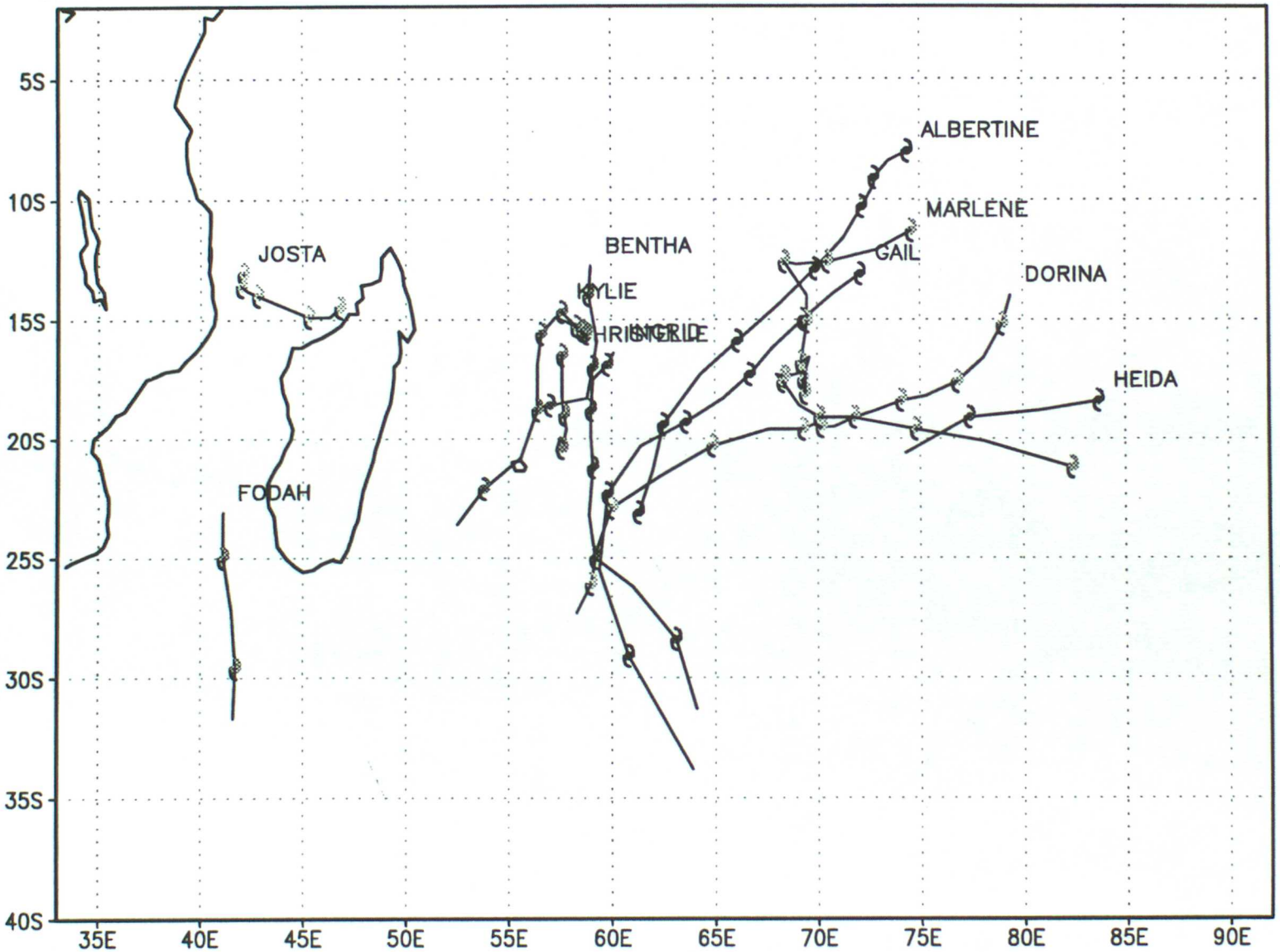
All errors are measured in kilometres

Sign Conventions

DPE values are always positive.
DX errors are positive if the forecast position lies eastwards of the observed position.
DY errors are positive if the forecast position lies polewards of the observed position.
AT errors are positive if the forecast position lies ahead of the observed position along the tropical cyclone track.
CT errors are positive if the forecast position lies right of the observed track in the northern hemisphere and left of the observed track in the southern hemisphere.

Figure 1

OBSERVED TRACKS of TROPICAL CYCLONES in the SOUTH–WEST INDIAN BASIN



ALBERTINE 941125 BENTHA 950104 CHRISTELLE 950107 DORINA 950121 FODAH 950125 GAIL 950206
HEIDA 950206 INGRID 950225 JOSTA 950308 KYLIE 950308 MARLENE 950331

KEY to DATE of FIRST SYMBOL

24 HOURLY OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

Figure 2
South-West Indian Tropical Cyclone Forecast Positional Errors

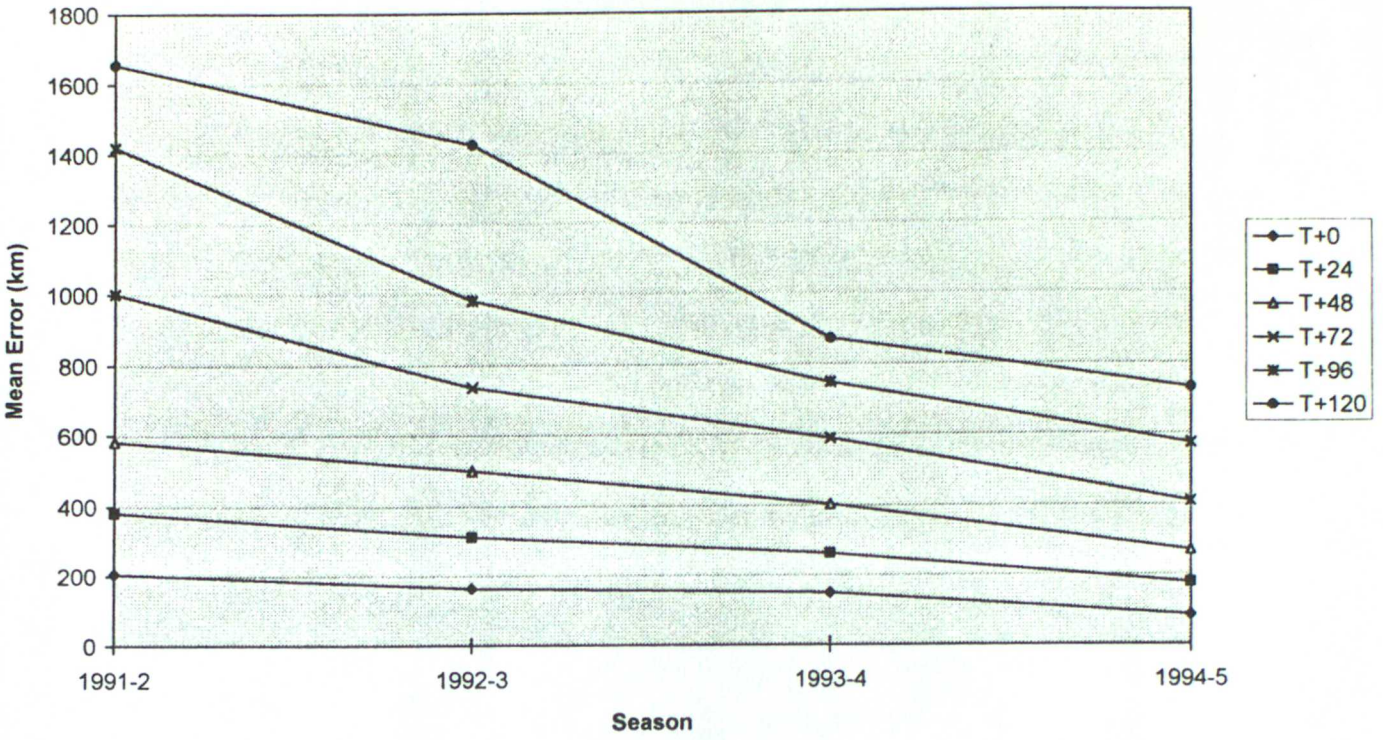


Figure 3
South-West Indian Tropical Cyclone Forecast Skill against CLIPER

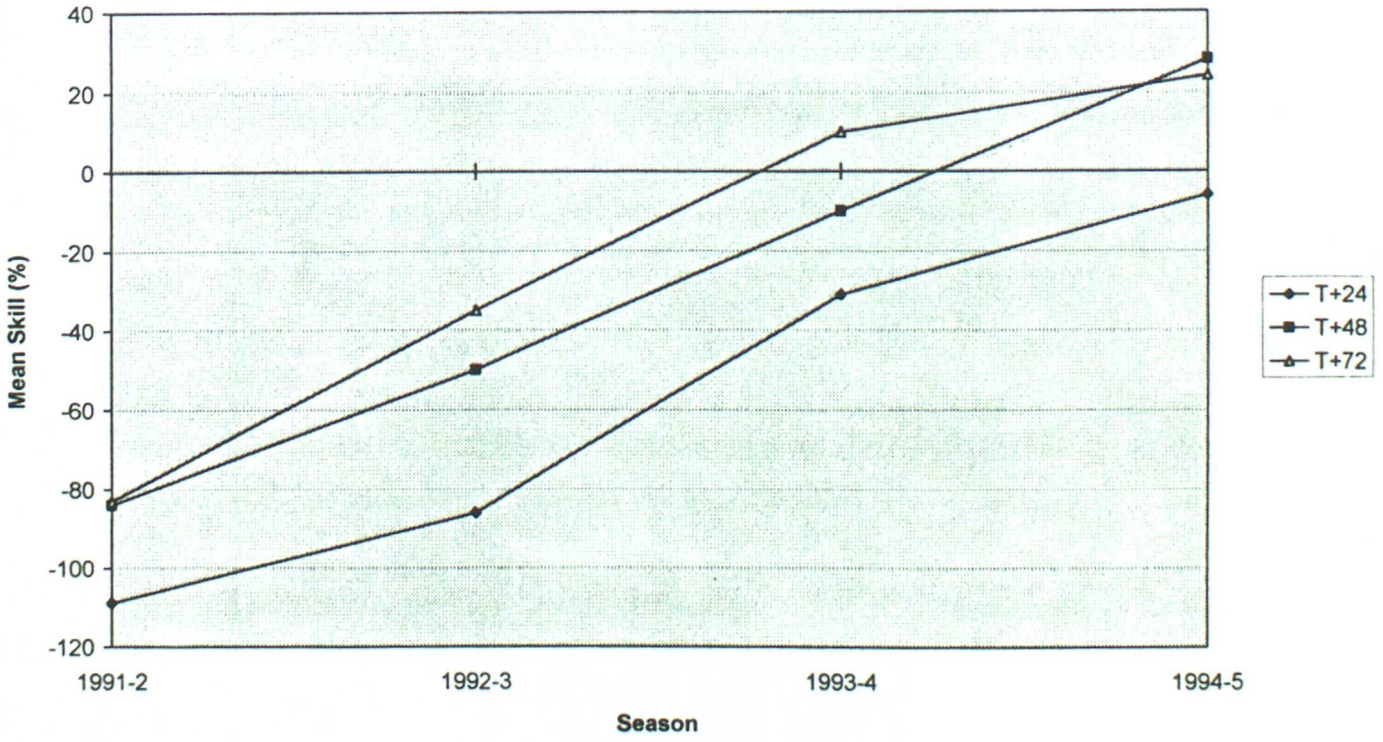
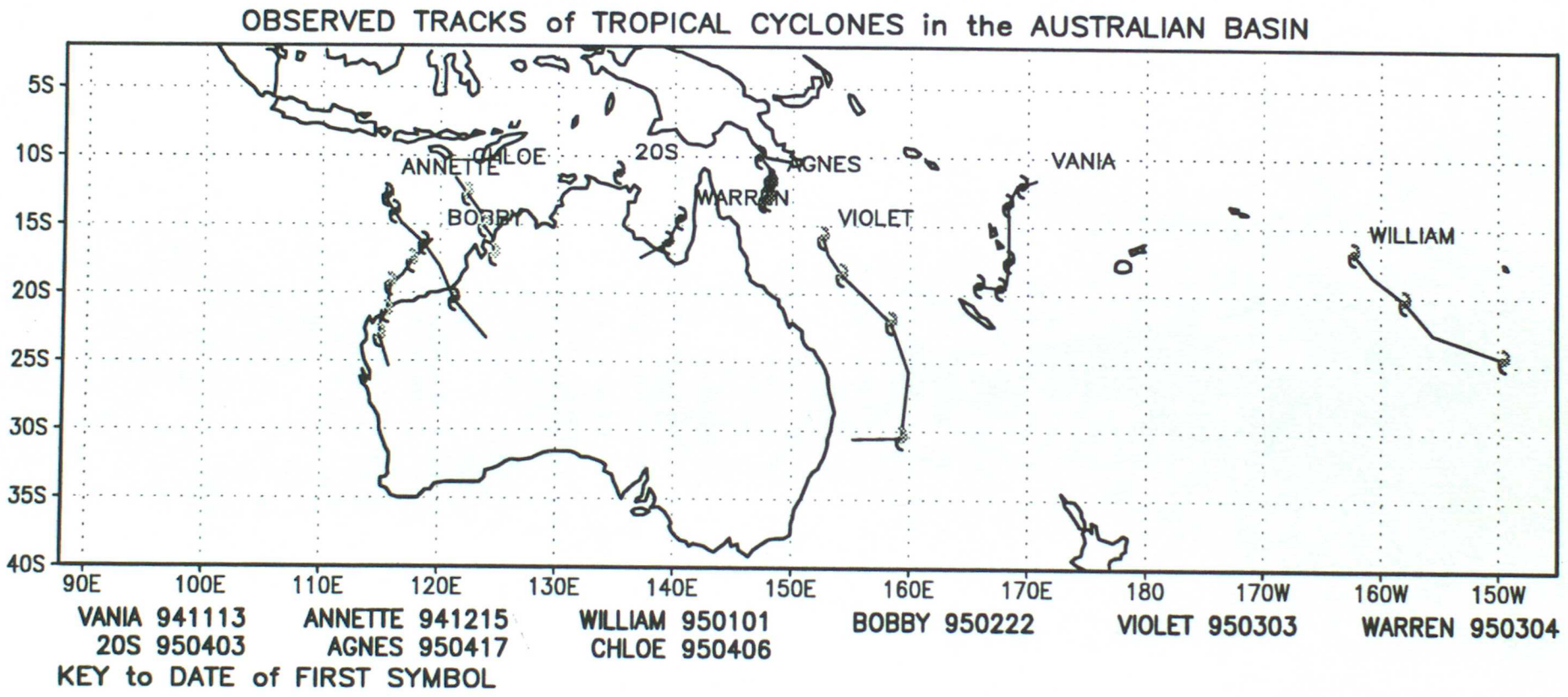


Figure 4



24 HOURLY OBSERVED POSITIONS

SYMBOLS REPRESENT 12Z POSITIONS

Figure 5
Australian Tropical Cyclone Forecast Positional Errors

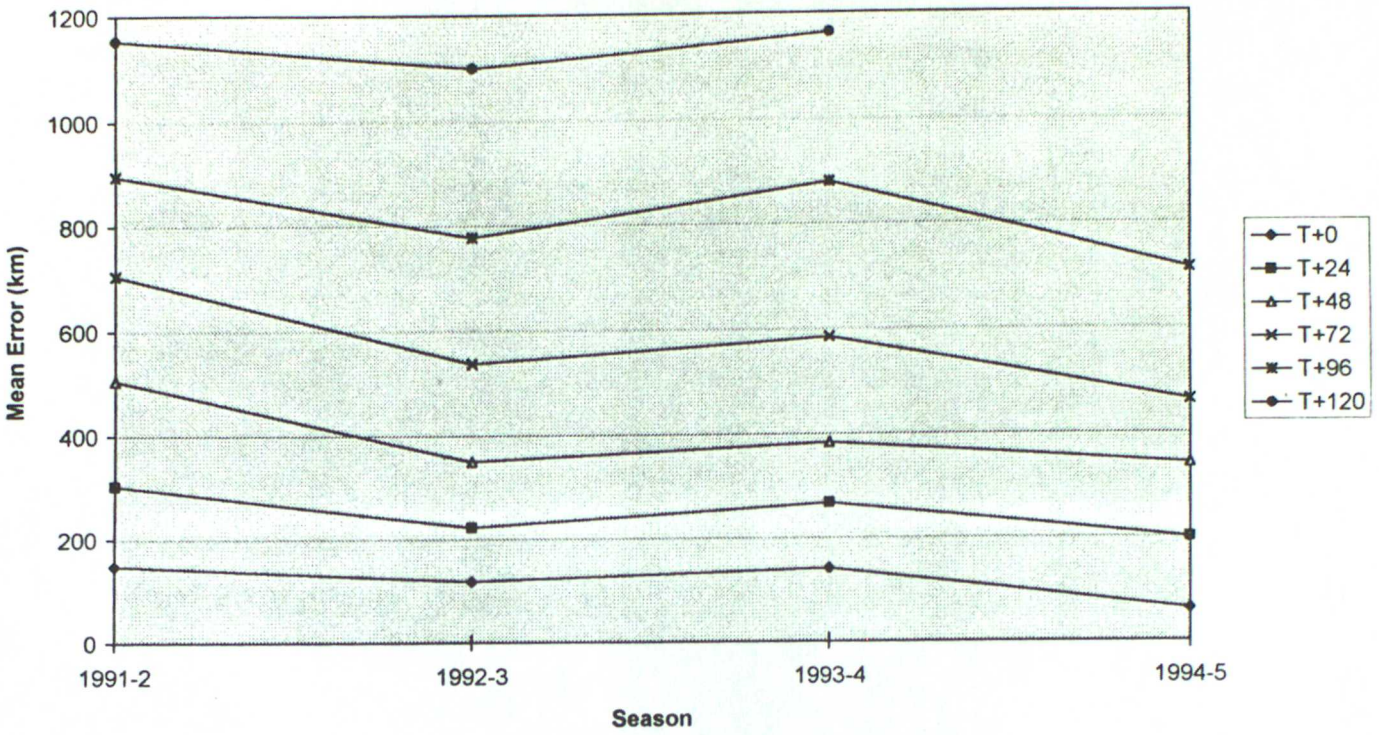


Figure 6
Australian Tropical Cyclone Forecast Skill against CLIPER

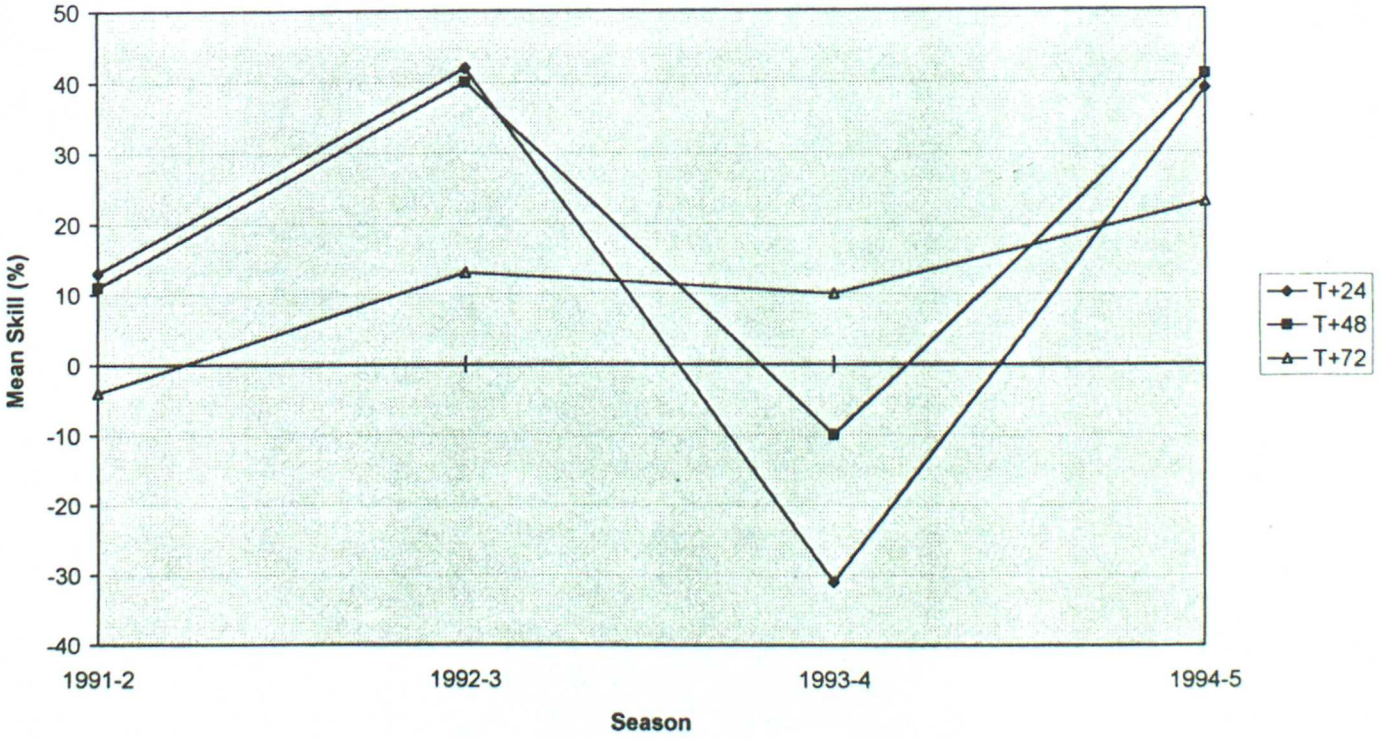


Figure 7
Southern Hemisphere Tropical Cyclone Forecast Positional Errors

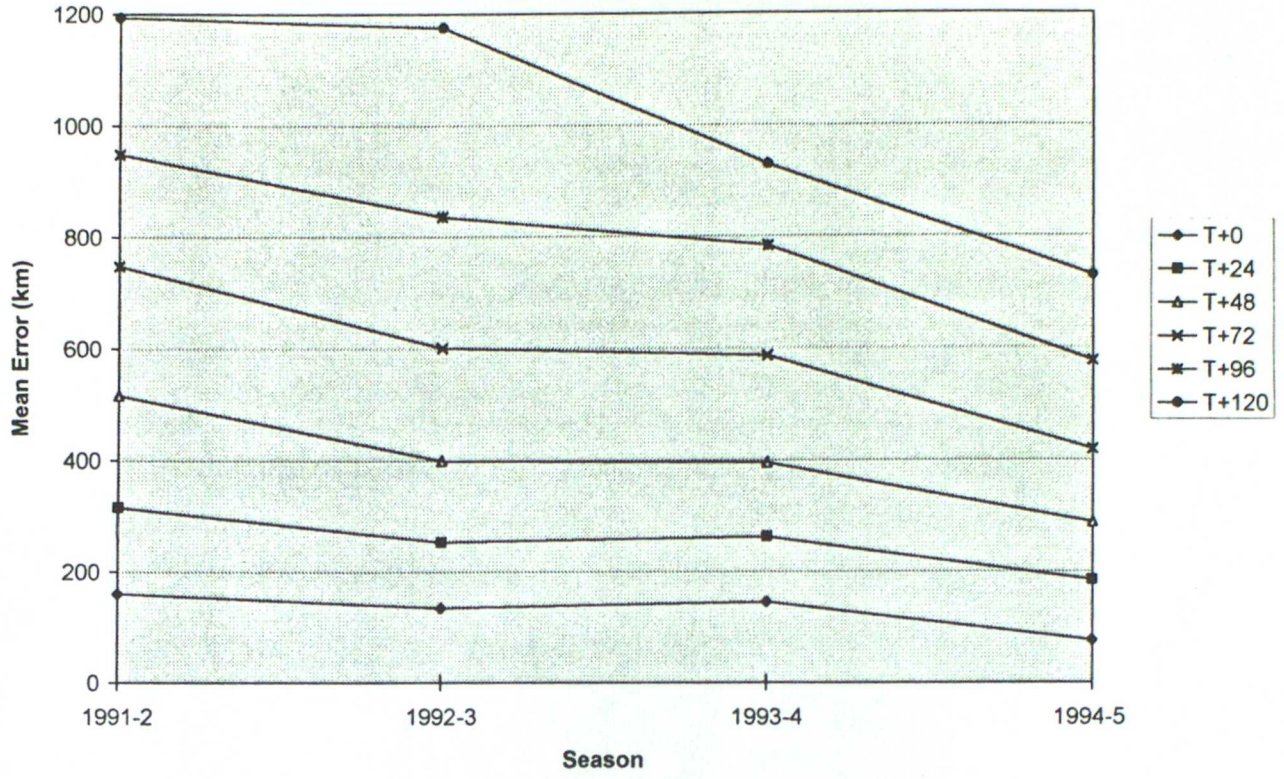


Figure 8
Southern Hemisphere Tropical Cyclone Forecast Skill against CLIPER